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The Coal Synfuels Industry: An Oil Vulnerability Issue [redacted] 25X1

An Intelligence Assessment

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GI 83-10111
May 1983

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The Coal Synfuels Industry: An Oil Vulnerability Issue [redacted]

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An Intelligence Assessment

This paper was prepared by [redacted] Office of Global Issues. Comments and queries are welcome and may be addressed to the Chief, Energy Issues Branch, OGI, on [redacted]

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The Coal Synfuels Industry: An Oil Vulnerability Issue [redacted]

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Key Judgments

Information available as of 1 April 1983 was used in this report.

Declining oil prices, escalating capital costs, and reduced government funding have caused massive cancellations and delays in coal synfuel projects around the world. These cutbacks [redacted] suggest to us that non-Communist production of synthetic fuels from coal will increase by less than 1 million barrels per day oil equivalent by the year 2000—approximately one-third the growth forecast by the International Energy Agency (IEA) in 1981. If this projection materializes, coal synfuels will do little toward reducing the non-Communist world's dependence on Middle East oil or Western Europe's and Japan's rising reliance on imported natural gas during the next two decades. 25X1

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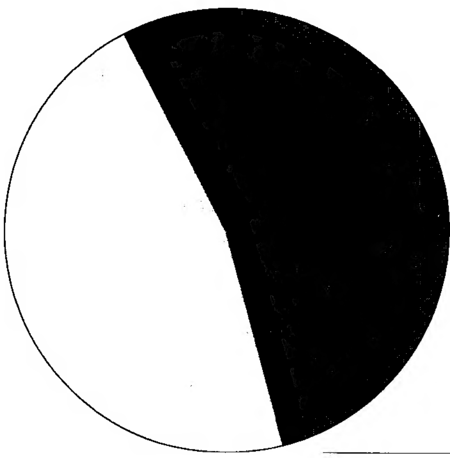
World Energy Reserves, 1983

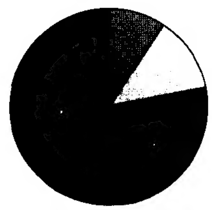
Percent

Coal
3,400 billion boe



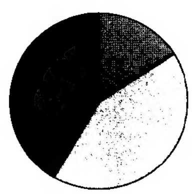
OECD	**45.8**
United States	27.8
United Kingdom	6.5
Australia	5.3
West Germany	5.0
Other	1.2
Communist Countries	**46.6**
USSR	24.1
China	14.4
Poland	4.5
Other	3.6
Other	**7.6**
South Africa	3.7
Other	3.9

Oil
670 billion barrels



OECD	**9.2**
United States	4.4
Other	4.8
Communist Countries	**12.7**
USSR	9.4
Other	3.3
Middle East	**55.1**
Saudi Arabia	24.2
Kuwait	9.6
Iran	8.3
Other	13.0
Other	**23.0**
Mexico	7.2
Libya	3.2
Venezuela	3.2
Other	9.4

Gas
540 billion boe



OECD	**15.9**
United States	6.7
Canada	3.2
Other	6.0
Communist Countries	**42.5**
USSR	41.0
Other	1.5
Middle East	**25.5**
Iran	16.0
Saudi Arabia	3.9
Other	5.6
Other	**16.1**
Algeria	3.7
Mexico	2.5
Other	9.9

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The Coal Synfuels Industry: An Oil Vulnerability Issue

Initial Optimism

Following the 1973 oil crisis, many observers believed that production of synthetic fuels from coal would grow rapidly. Coal synfuels technology had a long history of development, and recoverable world coal reserves were five times larger than those of oil (figure 1). Moreover, nearly 50 percent of proved recoverable coal reserves are in OECD nations; these countries account for less than 10 percent of proved oil reserves. With oil prices expected to continue rising rapidly, most analysts believed coal synfuels would be cost competitive by the mid-1980s. According to 1976 industry assessments, synthetic natural gas from coal was expected to cost about $19 per barrel of oil equivalent (boe) and coal-based syncrude about $25 per boe. At that time, the average price of OPEC oil was about $12 per barrel. The 1979 oil crisis added impetus to coal synfuels. The major impact was a surge in research and development (R&D) on coal synfuels technology; IEA member government expenditures on coal synfuels R&D and demonstration plants jumped from about $400 million in 1978 to more than $700 million by 1981 (table 1).

Table 1
Expenditures by Selected IEA Governments for Coal Conversion Research and Development

Million US $ at 1981 prices and exchange rates

	1978	1979	1980	1981
Total	**407.8**	**440.1**	**578.8**	**714.7**
Australia	NA	6.1	8.3	9.2
Belgium	1.4	0.3	1.9	6.4
Canada	2.6	2.3	3.8	7.2
West Germany	29.1	55.1	59.1	88.3
Japan	7.2	17.2	77.1	133.4
Netherlands	2.1	3.0	5.0	6.0
United Kingdom [a]	25.1	25.3	29.0	44.3
United States	340.3	330.8	394.6	419.9

[a] Includes expenditure by nationalized industries.

Growing Reservations

However, during the last two years—even before the recent decline in oil prices—numerous coal-based synfuel projects have been delayed or abandoned. Cutbacks stem largely from:

- Weak oil prices. Most industry forecasts now assume declining real oil prices to 1985, with prices remaining flat through 1990 and rising 1.5 to 3 percent per year during the 1990s.
- Sharply rising capital requirements. The estimated cost of a commercial-sized facility is at least $3 billion, and substantial cost overruns have been common.
- Reduced government funding because of burgeoning budget deficits and lower-than-expected growth in energy demand (table 2).
- The availability of cheaper alternatives to coal synfuels, such as Soviet natural gas in Western Europe.

Coal liquefaction efforts have been especially hard hit. Plans for the construction of the first commercial-scale direct liquefaction facility (SRC-II)—a joint venture between the United States, West Germany, and Japan—were canceled in mid-1981. In Australia—once the center for technology development—industry officials report that liquefaction projects have been sharply cut back. As for coal gasification, although some small, commercial-scale projects are proceeding, plans for large-scale plants have, for the most part, been scrapped. Three projects in the United States, for example, with a combined output of over 150,000 barrels per day oil equivalent (b/doe) have been canceled during the past 18 months. In Western Europe, Shell has withdrawn from two projects—the largest with an output of 40,000 b/doe—and Gasunie, the Dutch gas monopoly, has shelved plans for a 20,000 b/doe plant.

Table 2
Expenditures by Selected IEA Governments for Coal Liquefaction Research, Development, and Demonstration

Million US $ at 1981 prices and exchange rates

	1978	1979	1980	1981	1982
Total	**203.0**	**304.2**	**386.2**	**673.0**	**238.2**
Australia	2.1	3.6	5.2	1.6	2.1
Belgium				2.1	0.4
Canada [a]	1.3	1.2	1.5	1.7	1.9
West Germany	28.2	29.1	55.0	59.0	63.7
Japan	1.6	5.6	50.2	105.6	73.0
Netherlands	3.7	3.6	3.8	4.0	4.1
United Kingdom [b]	8.5	9.5	10.0	15.0	15.0
United States	157.6	251.6	260.5	484.0	78.0

[a] Secretariat estimate.
[b] Includes Secretariat estimate for nationalized industries.

[redacted]

Types of Coal Synfuels

From gasification:
- *Low-Btu gas (about 5,300 to 8,800 Btu per cubic meter), used for combined-cycle power systems.*
- *Medium-Btu gas (about 12,400 Btu per cubic meter), which can be transported short distances and used as a chemical feedstock, fuel gas, reducing gas for metallurgical purposes, and as an input to liquid hydrocarbon production.*
- *High-Btu gas (about 35,300 Btu per cubic meter, the same as natural gas) for use as pipeline-quality fuel.* [redacted]

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From liquefaction:
- *Synthesis gas, methanol, and synthetic petroleum liquids such as fuel oil, gasoline, diesel fuel, and kerosene.* [redacted]

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Synfuel Economics

The rise in the cost of producing coal synfuels has outpaced oil and gas price increases since 1973. As a result, despite today's higher oil prices, commercial production of coal synfuels is more difficult to justify on economic grounds now than it was a decade ago. Indeed, cost estimates for the SRC-II project soared from $1.4 billion in 1980 to nearly $3.4 billion in 1981 when the project was canceled. In Western Europe, the cost of a commercial-scale Dutch gasification plant more than tripled between 1979 and 1983 when it too was shelved. [redacted]

Escalating capital costs have been the key factor. Synfuel processes are highly capital intensive; capital charges account for about two-thirds of the product price of synthetic liquids, and the capital cost of a commercial-scale liquefaction plant is on the order of $120,000 per daily barrel of capacity (table 3). According to industry estimates, even the most expensive North Sea oilfields cost only $67,000 per daily barrel to develop. Given the disparity between these costs, most rational energy concerns would opt to invest in oilfields in the absence of some government subsidy or guarantee. [redacted]

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[redacted] the cost of coal synfuels from full-size plants using current technology probably will range between $60 and $100 per boe for liquids and between $35 and $65 per boe for synthetic natural gas. Considering the extensive work on coal synfuels to date, we foresee no major breakthroughs that would significantly reduce present cost estimates. [redacted]

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For coal liquefaction, price competitiveness with oil will probably not be reached during this century, even if real oil prices increase 3 percent per year. Capital needs of $3 billion or more for a commercial-scale liquefaction plant would still be a constraint on construction. Given current natural gas prices of about $27 per boe in Western Europe and $32 per boe in Japan, industry analysts believe synthetic natural gas could become cost competitive in the 1990s if gas prices rise. Once again, however, huge capital requirements are a major constraint. Some industry analysts contend, for example, that it would cost $54 billion to construct the necessary coal gasification plants to

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Table 3 *1982 US $*
Cost of Coal Synfuels: Liquefaction

Product cost (average)	79 per barrel
Based upon	
Plant capacity	50,000 b/d
Capital cost	6 billion
Fuel cost	28 per ton at 12,000 Btu/pound
Required rate of return	10 percent after tax
Tax rate	50 percent on profits after charging depreciation and interest
Debt:equity	50:50
Efficiency of conversion	55 percent
Operation and maintenance	5 percent per year of capital cost
Operational availability	85 percent of capacity, average per year
Plant life	20 years

Source: International Energy Agency.

equal the energy throughput of the Soviet gas pipeline. In contrast, West European construction and equipment loans for the pipeline now total about $8 billion.

Technology

Present synfuels production is based on coal conversion processes developed in the 1920s and 1930s. The techniques are not efficient; from 40 to 60 percent of coal's energy content is lost, with the higher losses occurring in the production of premium fuels. Gasification and liquefaction processes under development essentially represent an extension of existing technology.

most of the approximately 40 coal conversion processes under development outside the United States will not progress beyond the demonstration phase because of technical, economic, or marketing problems. All gasification and liquefaction processes, moreover, must undergo substantial additional development before large-scale plants can be built. 25X1

- Improved coal gasification techniques will not be ready for large-scale implementation until the late 1980s.
- Direct liquefaction processes will not be ready for commercial use until the early 1990s. 25X1

Coal Gasification. Low- and medium-Btu gas has been produced from coal for more than 100 years, and many plants are currently in operation. First-generation technology to produce high-Btu gas is proven and commercially available but is relatively expensive and inefficient. A commercial-scale plant (20,000 b/doe and up) based on more efficient second-generation processes and able to use a wider variety of coals has not yet been attempted. 25X1

Coal Liquefaction. Technology for liquefaction lags developments in gasification and appears even less attractive economically. The only commercially available process—used in South Africa's SASOL plants—produces medium-Btu gas from coal and then chemically combines the gas to form liquid products such as heating oil and gasoline. This two-stage operation, however, is extremely inefficient, using up more than half of the coal's energy content in the conversion process. Most analysts contend that the process is used in South Africa only because of large coal reserves, low mining costs, and Pretoria's willingness to subsidize production to lessen South Africa's vulnerability to an oil embargo. 25X1

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Second-generation liquefaction processes avoid the gasification step and liquefy the coal directly. Although several pilot plants have been constructed, none of the individual processes has been proven in sustained, large-scale operation, and numerous uncertainties remain. All of the processes, for example, involve preheating a slurry of pulverized coal and oil before liquefaction takes place, a step that remains difficult at sustained high operating rates with varying types of coal. Moreover, cancellation of the SRC-II project in 1981 means that large liquefaction

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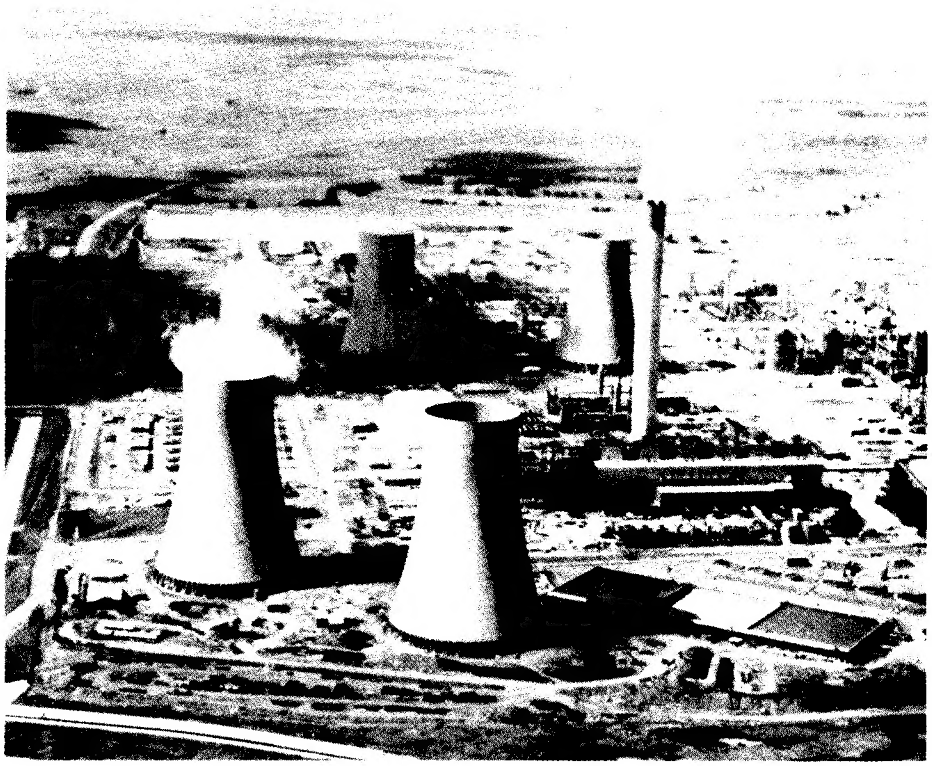
South Africa's SASOL II—the world's largest coal conversion plant—completed at a cost of nearly $3 billion.



World Synfuels ©

plants will now have to be scaled up from around 500 b/d—currently, the largest operating direct liquefaction facility—rather than from the 15,000 b/d capacity proposed for the SRC-II plant. According to press reports, cancellation of this project could delay commercialization of liquefaction technology by 10 years.

Synfuel Backers

South Africa. Determined to lessen its vulnerability to an oil cutoff, Pretoria is the world's leader in commercial-scale coal conversion. When the country's three SASOL plants are operating at capacity in 1985, they are scheduled to provide about 115,000 b/d of product and supply roughly half of South Africa's liquid fuel needs. Plans for the construction of a fourth plant (SASOL IV) are in the study phase. According to recent State Department reporting, South Africa must add a new synfuels plant the size of SASOL II or III every four or five years to maintain the percentage of its energy requirements produced from local sources.

West Germany. Building on established World War II technology and backed by government funding, West Germany is the world's leader in coal synfuels technology. Despite recent project cutbacks, the government remains committed to developing this technology, primarily for export. According to State Department reporting, two gasification projects and a liquefaction project probably will continue to receive partial (40 to 50 percent) government support. Under the government's proposed budget for energy R&D, coal synfuels have been allocated $900 million for the period 1982-85.

Japan. Dependent upon imported oil, primarily from the Middle East, for over 60 percent of its energy requirements, Japan remains active in developing coal synfuels. Three separate liquefaction processes now under development are to be combined into one process through the construction of a 750 to 1,500 b/doe pilot plant. Construction of a 150 b/doe liquefaction pilot plant in Australia is also proceeding under a Japanese-Australian joint venture agreement.

[redacted] Tokyo no longer expects to meet the goals set in 1979 for its alternative energy research program. While the program envisioned an annual synfuels output of nearly 600,000 b/doe in 1995, the [redacted] forecast places production at only 30,000 b/doe in 1995 and 50,000 b/doe in 2000. [redacted] 25X1 25X1 25X1

Outlook

Non-Communist production of coal-based synthetic fuels is approximately 300,000 b/doe, less than 1 percent of oil output. [redacted] 25X1
[redacted] given recent oil price developments, 25X1
we estimate that production will increase by less than 1 million b/doe by the end of the century—approximately one-third the growth forecast by the International Energy Agency in 1981. We believe that coal synfuels' lack of competitiveness with crude oil and natural gas and the huge capital costs of constructing large-scale synfuel plants will largely limit such ventures to relatively small facilities, each producing about 12,000 b/doe or less. These will be used to meet local needs and to test selected technologies. South Africa, we believe, will continue to be the major synfuel producer because of its desire to reduce dependence on imported oil. [redacted] 25X1

Because of the cancellation of many commercial-scale and demonstration plants, coal synfuels will provide little cushion in the event of an oil supply disruption. [redacted] facilities require up to six years for construction, and we believe the industry will lose critical technical and engineering skills as projects are canceled or postponed indefinitely. As with many other alternate energy processes that have proved to be uneconomic, we believe that decisions to proceed with coal synfuels production plans will be based on security-of-supply considerations and will require sizable subsidies. [redacted] 25X1 25X1

Advanced coal conversion technologies are in the relatively early stages of development. In light of this fact, we also believe that the Soviet Union and China—despite their vast coal reserves—are unlikely to commit increasingly scarce hard currency for large-scale synfuel projects incorporating untried Western technology. [redacted] 25X1

Soviet–West German Synfuel Project

Although the Soviets have been considering the purchase of a synfuels plant from the West Germans, prospects are not good for reaching an agreement in the near future. Coal liquefaction processes are still in the relatively early stages of development, and the Soviets are unlikely to commit their increasingly scarce hard currency for untried Western technology. [redacted]

The Negotiations

The Soviet Union and West Germany have been discussing a synfuels project since 1975. Recent press reports on the possibility of an agreement have been precipitated by the annual session of the Soviet–West German Economic Cooperation Commission. We have no evidence that an agreement has been reached and concluding one probably will be complicated. [redacted] *the Soviets are undecided between buying a synfuels plant outright, which could cost them upward of $3 billion, or more gradually developing their own technology—an option that would involve the West Germans in a less lucrative but extended technology transfer. Moreover, the West German firm with the only coal liquefaction process adapted to low-grade Siberian coal has not shown a willingness to transfer this technology to the USSR.* [redacted]

Implications of a Deal

Western coal conversion technology could enable the Soviets to exploit huge deposits of low-grade coal in remote Siberia. Conversion of coal to liquid fuel would enable Moscow to cut domestic consumption of oil, freeing additional quantities for hard currency export earnings. For the West Germans, success with a prototype plant in the Soviet Union could lead to followup orders from Moscow and elsewhere. In any agreement, however, the Soviets probably will insist on partial payment in gas or oil products—thereby slightly increasing West Germany's dependence on Soviet energy supplies. West German cooperation with the Soviet Union on coal liquefaction projects could also raise questions on the origin of some technology. Some West German firms are involved in US coal liquefaction projects, and any liquefaction plant constructed in the Soviet Union would include a large amount of refinery technology—technology that could come indirectly from the United States because of its lead in this field. [redacted]

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Technology

Despite serious research efforts during the past decade, Soviet *coal conversion technology is only in the pilot-plant stage of development. The Soviets are currently constructing a pilot plant, based on West*

German direct liquefaction technology developed before World War II, capable of producing 18 b/d of oil. The process, however, has serious technical problems and must be perfected before being used in a commercial-scale facility. The Soviets' dissatisfaction with their progress is evidenced by their attempts, during the past several years, to solicit cooperation in coal conversion technology from West German, Japanese, Italian, and US firms.

West Germany is the world's leader in synfuels technology. In the field of direct coal liquefaction, the West Germans have carried three processes through the pilot-plant stage: the Rheinbraun, Ruhrkohle/Veba, and Saarberg techniques. The largest pilot plant is capable of producing 400 to 500 b/d of oil. Commercial development of all three processes, however, is in doubt, pending a decision on government support. According to State Department reporting, only the Ruhrkohle/Veba process probably will be continued with government support; however, it has not been adapted to low-grade Siberian coal. West Germany is also the developer of the only proven indirect coal liquefaction process, involving gasification as an intermediate step. The one example of this technology in commercial operation is a SASOL plant in South Africa. This process is less efficient than the newer, direct liquefaction process the Soviets have expressed interest in. 25X1

Outside West Germany, the United States is probably the only country that could build a commercial-scale plant based on direct coal liquefaction technology. The Exxon donor-solvent process is the most advanced in the area of direct liquefaction, but it has not been adapted to low-grade Siberian coal. 25X1 Because of extensive German field experience, it is unlikely that the US technology could compete with available West German technology for handling low-grade Siberian coal. 25X1

The Soviets have recently contacted US firms to consider the design of a coal and methanol pipeline. The US-developed Texaco process of coal gasification could be used in an indirect liquefaction process to produce the necessary methanol. Coal gasification by the Texaco process could prove competitive with any West German methanol production process. We believe technological and economic constraints, however, will probably preclude the construction of a large-scale coal slurry pipeline during the 1980s.

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Appendix A

Foreign Coal Synfuels Plants

Location	Gasifier Type and Number	Dates	Coal Type	Product Gas (Application)	Capacity Per Unit [a] (MMSCFD)
Plants in operation [b]					
Bulgaria					
Dimitroffgrad	Winkler 4	1951 to present	NA	Medium Btu	16.1
Stara Zagora	Winkler 5	1962 to present	NA	Medium Btu	27
Czechoslovakia					
Chomutov	Woodall-Duckham 14	Present	Lignite	Low Btu (metalworks)	2 [c]
East Germany					
Schwarze Pumpe	Lurgi 24	1966 to 1980	Lignite	Medium Btu (town gas)	24
Schwarze Pumpe	Winkler 6	1950 to present	Lignite	Low Btu	58
Bohlen	Winkler 3	1938 to present	Lignite/coke	Syngas (hydrogen)	27
Bohlen	Lurgi 10	1940/43 [d]	Lignite	Medium Btu (town gas)	2.5 [c]
Zeitz	Winkler 3	1941 to present	Lignite	Syngas (hydrogen)	20
Karl-Marx Stadt	Koppers-Totzek 2	1966 to present	Oil residue (coke)	Syngas (ammonia)	13.4
West Germany					
Luenen	Lurgi 5	1969/70 to 1979	Subbituminous	Low Btu (gas turbine)	65 [c]
Great Britain					
Westfield	Lurgi 5	1960/62 to 1974	Bituminous/ subbituminous	Medium Btu (town gas)	9
Greece					
Ptolemais	Koppers-Totzek 6	1959/69/70 to present	Lignite	Syngas (ammonia)	6 to 9
India					
NA	Wellman-Galusha 6	NA	NA	NA	NA
Ramagundam	Koppers-Totzek (4-headed) 3	1980 to present	NA	Syngas (ammonia)	19
Korba	Koppers-Totzek (4-headed) 3	1972 [e] Construction nearly complete	NA	Syngas (ammonia)	19

Foreign Coal Synfuels Plants (continued)

Location	Gasifier Type and Number	Dates	Coal Type	Product Gas (Application)	Capacity Per Unit [a] (MMSCFD)
Talcher	Koppers-Totzek (4-headed) 3	1980 to present	NA	Syngas (ammonia)	19
Jealgora	Lurgi 1	1961 to present	Various	NA	NA
Asansol	Riley-Morgan 2	1952/68 to present	Bituminous	NA	NA
Madras	Winkler 3	1961 to 1979	Lignite (now oil)	Syngas (ammonia)	17.8
Portugal					
Lisbon	Koppers-Totzek	1956 to present	Lignite/ anthracite	Syngas (ammonia)	4 [c]
South Africa					
Sasolburg (SASOL I)	Lurgi 17	1954/58/ 66/73/80 to present	Subbituminous	Syngas (liquid hydrocarbons, ammonia, fuel gas)	33 to 100
Secunda (SASOL II)	Lurgi 36	1979/80 to present	Subbituminous	Syngas (liquid hydrocarbons)	33
Modderfontein (Johannesburg)	Koppers-Totzek 6	1974 to present	Bituminous	Syngas (ammonia)	14 [c]
Vaal Potteries	Wellman-Galusha 1	1955 to present	NA	Low Btu (furnace)	NA
Union Steel	Wellman-Galusha 7	1951 to present	NA	Low Btu (metalworks)	NA
Rand Brick	Wellman-Galusha 1	1949 to present	NA	Low Btu (brick kiln)	NA
Scaw Metals	Wellman-Galusha 1	1955 to present	NA	Low Btu (metalworks)	NA
Lydenberg	Stoic 1	1976 to present	Bituminous	Low Btu (metalworks)	NA
Driefontein	Stoic 1	1973 to present	Bituminous	Low Btu (brick kiln)	NA
Pretoria	Riley-Morgan 7	1933/41 to present	Bituminous	Low Btu (metalworks)	2 [c]
Dundee	Riley-Morgan 2	1950 to present	Bituminous	Low Btu (glassworks)	2 [c]
Springs	Woodall-Duckham 2	Present	Bituminous	Low Btu	NA
Meyerton	Woodall-Duckham 1	Present	Bituminous	Low Btu (furnace)	NA
Johannesburg	Woodall-Duckham	Present	Bituminous	Low Btu (steelworks)	NA
Stewarts and Lloyds	Woodall-Duckham	Present	Bituminous	Low Btu (steelworks)	NA
Escault	Woodall-Duckham 3	Present	Bituminous	Low Btu (furnace)	NA

Foreign Coal Synfuels Plants (continued)

Location	Gasifier Type and Number	Dates	Coal Type	Product Gas (Application)	Capacity Per Unit [a] (MMSCFD)
Mandini	Woodall-Duckham 2	Present	Bituminous	Low Btu	NA
Driefontein	Woodall-Duckham 2	Present	Bituminous	NA	NA
Vereenigning	Woodall-Duckham 3	Present	Bituminous	Low Btu (refractory works)	NA
Stewarts and Lloyds	Wellman-Incandescent	Present	Bituminous	Low Btu (steelworks)	NA
Cullinan	Wellman-Incandescent 4	1964/65/73 to present	Bituminous	Low Btu (refractory works)	NA
Scaw Metals	Wellman-Incandescent 5	1963/68/75 to present	Bituminous	Low Btu (metalworks)	NA
Johannesburg	Wellman-Incandescent 6	1963/68/75 to present	Bituminous	Low Btu (metalworks)	NA
Alusaf	Wellman-Incandescent 6	1978 to present	Bituminous	Low Btu (metalworks)	NA
Grootfontein	Wellman-Incandescent 1	1970 to present	Bituminous	Low Btu (metalworks)	NA
South Cross Steel	Wellman-Incandescent 4	1968/76/80 to present	Bituminous	Low Btu (steelworks)	NA
Highveld Steel	Wellman-Incandescent 6	1968/76 to present	Bituminous	Low Btu (steelworks)	NA
USCO	Wellman-Incandescent	1973 to present	Bituminous	Low Btu (steelworks)	NA
Saiccor	Wellman-Incandescent	1973 to present	Bituminous	Low Btu (paperworks)	NA
Union Steel	Wellman-Incandescent	1965/68 to present	NA	Low Btu (steelworks)	NA
Consolidated Glass	Wellman-Incandescent	1967 to present	NA	Low Btu (glassworks)	NA
Thailand					
Lampang	Koppers-Totzek 5	1963/66 to present	Lignite	Syngas (ammonia)	10 [c]
Turkey					
Kutahya	Koppers-Totzek 4	1966 to present	Lignite	Syngas (ammonia)	9 [c]
Kutahya	Winkler 2	1959 to present	Lignite	Syngas (ammonia)	9 [c]
Istanbul	Woodall-Duckham 1	NA	Lignite	NA	NA

Foreign Coal Synfuels Plants (continued)

Location	Gasifier Type and Number	Dates	Coal Type	Product Gas (Application)	Capacity Per Unit [a] (MMSCFD)
USSR					
Salawad	Winkler 7	1950 to present	NA	Medium Btu	21
Baschkirien	Winkler 4	1950 to present	NA	Medium Btu	57
Yugoslavia					
Jendinjenja	Wellman-Galusha 1	NA	NA	NA	NA
Gorazde	Winkler 1	1952 to present	Subbituminous	Syngas (ammonia)	6.3
Kosovo	Lurgi 6	Present	Lignite	Syngas (ammonia)	11.2
Zambia					
Kafue	Koppers-Totzek 4	1967/74/ 75 to present	Bituminous	Syngas (ammonia, methanol)	9 [c]
Plants under construction or in engineering design phase					
Brazil					
San Jeronimo	Koppers-Totzek 2	1984	Subbituminous	NA	34 [c]
Campo Largo	Carbogas-Pentagano	1980	Subbituminous	Low Btu (fuel gas)	3
China					
Beijing	Lurgi 4	1978 [e]	Semi-anthracite	Syngas (ammonia)	30 [c]
Poland					
Katowice	Koppers-Totzek 3	1982/83	Subbituminous	Medium Btu (fuel gas)	35
South Africa					
Secunda (SASOL III)	Lurgi 36	1984	Subbituminous	Syngas (liquid hydrocarbons)	33

[a] Million standard cubic feet per day.
[b] Facilities that are currently operating or have been shut down for less than five years.
[c] Approximate.
[d] Some units of this plant started operation in 1949, others in 1943; current status unknown.
[e] Date of order.

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Appendix B

Emerging Coal Synfuels Technologies

Tons of coal per day
(except as noted)

Country/Process	Size of Largest Pilot Plant	Location of Largest Pilot Plant	Proposed Commercial Sites	Proposed Commercial Plant Size	Official Status
Gasification					
West Germany					
Shell Koppers	150	Hamburg, West Germany			Continuing in-house research and feasibility studies, no commercial plant announcements. Intended plans have been canceled for West Germany.
High Temperature Winkler	24	Frecher, West Germany	Huerth-Berhenrath, West Germany [a]	6,700	No government support, commercial plant under construction at Rheinbraun.
Saarberg-Otto	264	Volklinger-Fursten-hausen, West Germany			Government support ending soon, no commercial plans announced.
RAG/RCH Texaco	144	Oberhausen/Holten, West Germany	Muscle Shoals, United States; [a] Cool Water Project, United States; [a] Tennessee Eastman, United States [a]	NA	Government interested in supporting commercial demonstration plant in West Germany.
Ruhr-100 High Pressure Lurgi	135	Dorsten, West Germany			Government support ending soon, no commercial plans announced.
KGN Fixed Bed	2	Huchelhoven, West Germany	Huchelhoven, West Germany	5,500	State government of Nordrhein, Westfalia, is expected to fund project through demonstration phase.
VEW Partial Gasification (combined cycle)	360	Stockum, West Germany	Gersteinwerke, West Germany	5,500	Commercialization prospects are low with government support expected to end.
Bergbau-Forschung Nuclear Assisted	10.8	Essen, West Germany			Research continues, no commercial plans announced.
Rheinbraun Nuclear Lignite Hydrogasification	25	Wesseling, West Germany			Research continues, no commercial plans announced.
Kloeckner Molten Iron	240	Ruhr region, West Germany	NA	1,900	Government interested in supporting commercial demonstration plant in West Germany.
Steag/Lurgi (combined-cycle)			Lunen, West Germany [a]	1,700	Commercial-sized facility shut down for economic reasons.

Emerging Coal Synfuels Technologies (continued)

Tons of coal per day
(except as noted)

Country/Process	Size of Largest Pilot Plant	Location of Largest Pilot Plant	Proposed Commercial Sites	Proposed Commercial Plant Size	Official Status
Great Britain					
British Gas Slagging Lurgi	800	Westfield, Scotland			British Gas is trying to find a sponsor for commercialization.
British Gas Composite					British Gas has dropped this project.
Esso Chemical Active	3.6	Abington, England	NA	20 MW	Proposed plant does not appear to be ready for commercialization.
National Coal Board PFB (pressurized fluidized bed combustion of coal) [b]	5 MW	Leatherhead, England	Grimethorpe, England [a]	20 MW	Testing of the demonstration-sized unit through 1982.
India					
Central Fuel Research	24.0	Dhambad, India			Experimental research facility in operation since 1962.
Bharat Heavy Electrical	144.0	Trichy, India [a]	Tiruchirapalli, India [a]	5 MW	Demonstration unit undergoing testing.
Japan					
Sumitomi Molten Iron	60	Kashima, Japan			Plans call for the construction of a demonstration plant in Japan and Australia.
Mitsui M. Gas	NA	Kitakyusha, Japan			Still in early phases of pilot-plant testing.
Coal Mining Research (combined cycle)	40	Yubari, Hokkaido, Japan	NA	1,000	Pilot plant still in testing phase.
Hitachi Coal Oil Mixture	4	Iawki City, Japan			Plans call for construction of a 40 ton per day pilot plant.
Soviet Union					
Power Engineering High Speed Pyrolysis (fixed bed)	100-200	Kaliningrad, USSR	Kansk-Achinsk, USSR	175 tons per hour (demonstration plant)	Demonstration plant at Karsnoyarsk still under construction. Proposed commercial plant at Kansk-Achinsk will have capacity of 25 million tons per year.
Liquefaction					
West Germany					
Ruhrkohle/ Veba Oil Catalytic Hydrogenation	200	Bottrop, West Germany	NA	11,250	Commercial development in doubt pending decision on West German support.
Saarbergwerke Catalytic Hydrogenation	6	Volklinger-Furstenhausen, West Germany	NA	7,000	Commercial development in doubt pending decision on West German support at end of pilot-plant tests in 1983.
Rheinbraun	0.3	Wesseling, West Germany	NA	6,000	Commercial development in doubt pending decision on West German support.

Emerging Coal Synfuels Technologies (continued)

Tons of coal per day (except as noted)

Country/Process	Size of Largest Pilot Plant	Location of Largest Pilot Plant	Proposed Commercial Sites	Proposed Commercial Plant Size	Official Status
Great Britain					
National Coal Board Supercritical Gas Solvent Extraction	2.7	Stoke Orchard, England			Commercial development unlikely in the near term because of National Coal Board R&D cutbacks.
National Coal Board Liquid Solvent Extraction	0.7	Stoke Orchard, England			Commercial development unlikely in the near term because of National Coal Board R&D cutbacks.
Australia					
CSIRO High Speed Flash Pyrolysis	0.5	North Ryde, England			Research is still under way, but no commercial plans have been announced.
Poland					
Central Mining Institute Catalytic Hydrogenation	0.12	Tychy-Wyry, Poland			Still in the early phases of research.
South Africa					
SASOL (Lurgi/Fischer Tropsch)			Sasolburg (SASOL I), SA [a]	11,000	Commercial operation since 1955.
			Secunda (SASOL II and III), SA [a]	60,000	Full commercial operation of both facilities by end of 1982.
South African Explosives and Chemicals Koppers Totzek			Modderfontein, SA [a]	1,000	Commercial operation since 1972 for ammonia production.
South African Explosives and Chemicals/Mobil			Modderfontein, SA	2,400	Status of this development in doubt. Methanol production intended.
SASOL Direct Liquefaction	Bench scale	Sasolburg, SA			Still in the early experimental phase of development.
Japan					
Mitsui Solvent Refined Coal	4.5	Ohmuta City, Japan	Victoria, Australia	5,500	Recent announcements have indicated that construction of the demonstration facility has been postponed indefinitely.
Nippon Brown Coal "Kominic" Direct Hydrogenation	0.55	Osaka, Japan	Victoria, Australia	5,000	Construction of a 50 ton per day demonstration plant in Australia should be completed in 1983.
Mitsui Engineer and Ship Building Direct	2.4	Kawasaki, Japan	NA	500	Pilot plant still in early research stage.
Sumitomo Solvent Extraction	1	Ibaraki Prefecture, Japan	NA	250	Pilot plant still in early research stage.
Mitsubishi Heavy Ind. Solvolysis	1	Nagasaki, Japan			Pilot plant planned at 40 ton per day input.

Emerging Coal Synfuels Technologies (continued)

Tons of coal per day
(except as noted)

Country/Process	Size of Largest Pilot Plant	Location of Largest Pilot Plant	Proposed Commercial Sites	Proposed Commercial Plant Size	Official Status
Soviet Union					
Institute of Mineral Fuels Catalytic Hydrogenation	0.1	Moscow, USSR			Pilot plant in construction at Belkovskaya mine (10 tons per day). Plans call for construction of pilot plant at Kansk-Achinsk (75 tons per day).

[a] Already under construction or completed.
[b] Noted here because of potential competition with combined-cycle coal gasification for electric power generation.

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